3. *Theme 1: Sources of the Solar Wind*

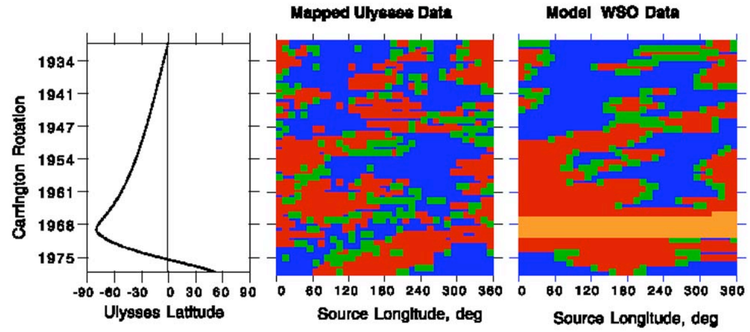

Figure 3.1. (left) Ulysses' latitude vs. Carrington rotation. (middle) Magnetic polarity of the HMF at Ulysses, mapped back onto Carrington rotation and longitude on a 2.5 solar radii source surface. (right) The magnetic polarity expected at the Ulysses' footpoint on the source surface using the WSO potential-field source surface model. Red (blue) denotes outward (inward) field and orange denotes implied outward field [Neugebauer et al., 2002].

__Research Objectives for FY2001-2004 from the Ulysses 2001 Senior Review Proposal__

(1) Identify solar wind sources by conducting magnetic field, plasma, composition, and energetic particle observations as polar coronal holes grow and Ulysses descends from high northern latitudes.

(2) Characterize the solar polar magnetic field and its evolution [during U-II].

(3) Analyze the 3D structure and evolution of overexpanding CMEs during the maximum and declining years of the solar cycle.

(4) Combine composition measurements from Ulysses, ACE and SOHO to analyze fractionation processes in the solar wind.

(5) Find a viable acceleration mechanism to create the ubiquitous tails on the distribution functions of pickup ions.

(6) Use Ulysses type III radio observations to monitor solar flare activity on the far side of the Sun from the Earth and to develop radio-tracking methods for the STEREO mission.

(7) Look for more solar flares with energies comparable to that of the 1991 June 1 event, whose energy output appears to involve the global corona.

__Accomplishments in 2001-2003__ and __Objectives for 2004-2005 and 2006-2007__

Sources of the solar wind:

In U-I, the technique of mapping the solar wind back to the Sun using a source surface model of the corona was applied with only marginal success. Still, it showed differences between observations and expectation. In U-II, ballistic mapping and source surface models have been further developed to the point that they are reliably used to determine the sources of the solar wind (Fig. 3.1; Liewer et al., [2002]). For the 2001 solar maximum, the mapped and observed polarities were in good agreement at intermediate latitudes. Solar wind mapped to *both* coronal holes and active regions, a finding which differs from those in 1994-1995 when solar activity was very low. Active region flows appear to be organized into several substreams. A numerical 3D MHD model was used to further explore the evolution of the HCS around solar maximum. It was found that the HCS often maintains its structure over the course of several solar rotations (Fig. 3.2 [Riley et al., 2002]). Further work is required to enable the mapping at high latitudes.

In 2003-2004, Ulysses and observations near the ecliptic will characterize the configuration of the HCS and speed minimum in the declining phases of the solar cycle and show the effect of corotating interaction regions (CIRs). During 2005-2007, Ulysses will travel from 5 AU (in 2005) in to 2 AU (in 2007) in the latitude zone in which streams are interacting due to solar rotation. The dynamics in

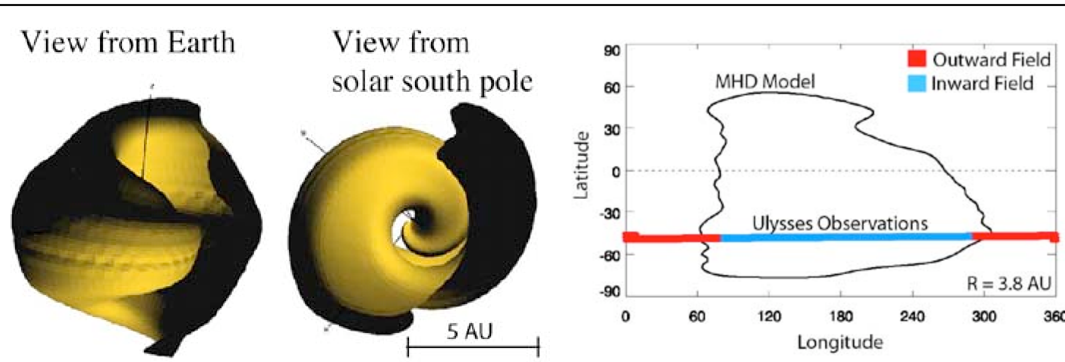

Figure 3.2. 3D surface plot of the HCS for CR1961 - April 2000 (left). Cut through the HCS at 3.8 AU (right) and comparison with Ulysses. [Riley et al., 2002]

the interior of the interaction regions can be studied. Theoretical models have yet to be compared with these observations. This is an important part of predicting solar wind variability under LWS. In 2006-2007, mapping to the Sun at the highest latitudes will receive the additional development it needs for studying polar fields.

Topology of the HCS:

The HCS is a marker for patterns of solar wind flow, reflecting the magnetic control of the coronal expansion. Ulysses suprathermal electron, energetic particle, plasma and field data show it can both consist of multiple current sheets and be folded back toward the Sun [Kahler et al., 1998; Crooker et al., 2001]. With the launch of ACE and Wind, and anticipated STEREO launch, in *UFC* it will be possible to use widely distributed measurements to conduct a global analysis of 3D structure of the HCS.

Polar cap magnetic field:

A technique has been developed to infer the strength of the solar polar cap magnetic field using Ulysses data [Smith et al., 2002]. This technique will be applied to new phases of the solar cycle in *UFC*. Since the method depends on excursions into the fast polar coronal hole (PCH) flow, only Ulysses will have this capability. The polar cap field cannot be accurately measured from the ecliptic.

Quadrature observations:

Ulysses-SOHO quadrature studies compare *in situ* solar wind measurements with remote coronal sensing of the same plasma at the Sun. SOHO instruments determine coronal morphology, density, temperature, flow speed, and composition in solar wind forming regions. Recent results show, e.g., that acceleration occurs more slowly in small, equatorial coronal holes than in PCHs [Poletto et al, 2002]. Ulysses is the only existing spacecraft able to make the *in situ* measurements necessary for quadrature studies. Quadratures occur twice a year and observations will continue as Ulysses follows the HCS down in latitude during 2004-2007. SDO, Solar-B, and STEREO will add new opportunities for quadrature studies in *UFC*.

CMEs:

Ulysses discovered over-expanding CMEs at high southern latitudes in 1993-1996. No further examples were observed until 2001 [Reisenfeld et al., 2001], shortly after solar activity maximum and at high northern latitudes. Events of this nature have not yet been identified near the ecliptic plane and it is not known how over-expansion relates to characteristics of CMEs close to the Sun since all but two of the events occurred before the launch of SOHO. To gain understanding, a combination of remote (SOHO, STEREO, SDO) and *in situ* (*UFC*, ACE, Wind, STEREO, Cassini) measurements at low and high latitudes will be used together with heliospheric imager (the first, SMEI, launched in January 2003) and interplanetary scintillation (IPS) observations. More generally, multipoint measurements will be used with Ulysses high-latitude measurements to analyze the evolution and overall magnetic structure and topology of CMEs in the solar wind as functions of heliocentric distance and latitude, as the Sun moves towards the next solar maximum.

Abundance of ^{3}He in the solar wind and deuterium in the outer convection zone (OCZ):

The protosolar deuterium to hydrogen ratio (D/H) is important for studies of galactic chemical evolution [Holweger, 2001]. The protosolar cloud (PSC) value is as yet poorly determined. One method to do this uses the present ^{3}He abundance in the solar wind and the known PSC value of ^{3}He /^{4}He [Geiss and Gloeckler, 2003]. Ulysses/SWICS has measured the helium isotopes not only in the slow wind but also in the high-speed streams coming out of large PCHs. To reduce errors and gain confidence in the linear regression method using this data to determine the OCZ ^{3}He/^{4}He ratio, it is important to repeat the measurements during the next solar minimum (2005-2008) in the high-speed solar wind at high latitudes in *UFC*. Measurements of these same ratios at 1 AU in the ecliptic with

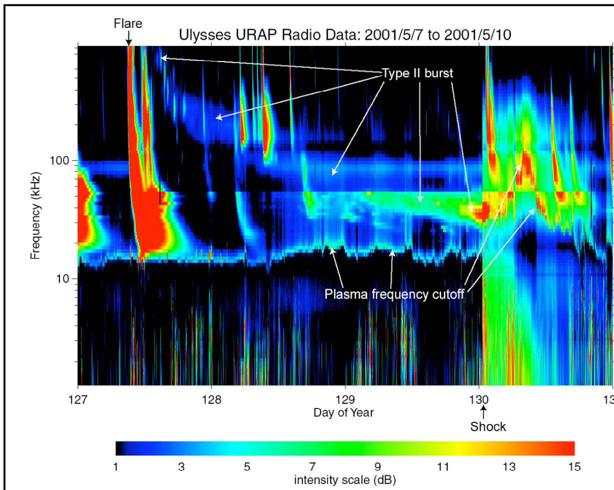

Figure 3.3. Radio intensity from the URAP for a 4-day interval covering the passage of a CME from the Sun to Ulysses. A CME-driven shock produces type II radio emission, which tracks from high to low frequencies with increasing distance from the Sun. CME-associated flaring activity produces the intense, fast drift (type III) radio burst beginning at 9:00 on day 127. Shock arrival occurs on day 131.

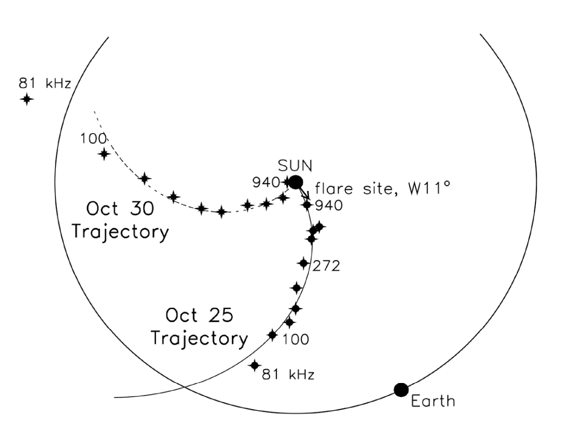

Figure 3.4. Ulysses/URAP trajectories for type III exciter electrons from two 1994 solar flares. Ulysses was south of the ecliptic, permitting determination of the ecliptic trajectories [Reiner et al., 1995].

ACE, not available during U-I, will enable separating temporal from spatial effects by making co-temporal slow and fast, low latitude and high latitude wind measurements.

Radio, in situ, and remote sensing of the heliosphere. *STEREO*:

Ulysses tracks CME-driven shocks through the interplanetary medium with observations of the radio emission from shock accelerated electrons. This emission, type II radio bursts, links coronal events to *in situ* activity (Fig. 3.3). Combined Ulysses and Wind radio data are being used to develop techniques for 3D tracking of CME-driven shocks for use with STEREO observations.

Solar Energetic Particles (SEPs):

Ulysses locates flare sites and associated SEP sources using type III solar radio bursts, produced by 1-10 keV solar flare electrons (Fig. 3.4; Reiner et al, [1995]). Recent achievements are: (i) Definitive demonstration that some type III emission occurs at the fundamental of the electron plasma frequency. (ii) 3D triangulation of type III burst trajectories using Ulysses and Wind. (iii) Ulysses' remote detection of type III radio activity from flare sites on the opposite side of the Sun from the Earth. Also, Cane et al. [2002] find that long duration type III bursts are correlated with SEP events produced by large CMEs and suggest that those type III burst electrons are accelerated in CME wakes.

Solar flares and type III radio burst activity are strongly correlated with the solar cycle. Fig. 1.2 shows that 2003-2004, will offer the opportunity to observe type III emissions from mid- and low latitudes when there is still a moderate level of activity. During 2005-2006 there will be few radio bursts, but observations will be made from high latitudes to provide a good perspective to compare with STEREO observations starting in late 2005. The Sun will be moving towards solar maximum in 2007, providing an excellent opportunity to jointly view type III emission with STEREO during *UFC*-FLS. Ulysses radio and particle data will be used to study the Cane et al. [2002] hypothesis and its consequences for particle acceleration and space weather prediction in 2003-2005 and 2007-2008. The remote detection of backside Type III events will be extended into the beginning of the next solar cycle, during *UFC*-FLS.

Suprathermal tails:

A fundamental discovery of Ulysses are the ubiquitous suprathermal tails on ion velocity distributions [Gloeckler 2003]. These were expected in the downstream regions of shocks. But, weaker suprathermal tails also exist during shock-free periods and even in the super-quiet wind of PCHs. The inner-source pickup ion tails are a potential source of seed particles for accelerated energetic particles, including anomalous cosmic rays (ACRs). It is thus important to understand the development of the tails as an initial step in the process of particle acceleration. At present these tails have been measured only for C^{+} with poor statistical accuracy [Gloeckler et al., 2000a]. To study the inner-source tails and their evolution with distance requires both Ulysses and ACE observations over an extended period.

Comparing Ulysses and ACE measurements in

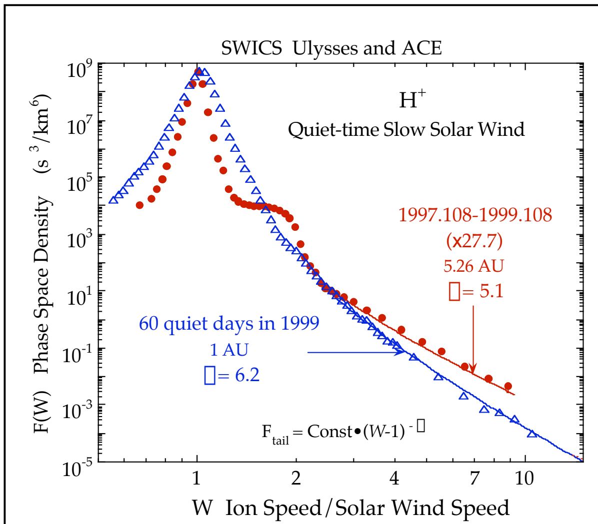

Figure 3.5. Quiet-time proton spectra at 1 and 5.26 AU. The Ulysses spectrum is extrapolated to 1AU. The tail at Ulysses (red) is harder (less steep) and its intensity higher than that of the tail measured at 1 AU by ACE (blue).

Table 3.1; *Topical list of 2004-2007 objectives - Sources of the Solar Wind*
▪ Map solar wind source regions and the polar cap magnetic field strength as polar coronal holes are growing and moving equatorward during the declining phase of solar activity. (2004-2005)
▪ Use Ulysses, ACE, Wind, and STEREO to analyze the 3-D structure of the HCS during *UFC-FLS*. (2006-2007)
▪ Serve as the in situ source of solar wind observations during quadrature studies with SOHO and other solar limb observing investigations. (2004-2005, 2006-2007)
▪ Conduct global studies of the structure and propagation of over-expanding and other CMEs. (2004-2007)
▪ Improve the statistical accuracy of $^3He/^4He$ measurements in the solar outer convection zone, to refine our knowledge of D/H values for the protosolar cloud. (2005-2006)
▪ Carry out joint Ulysses-ACE-Cassini observations of inner source pickup ion suprathermal tails and determine their evolution with distance from the Sun. (2004-2007)
▪ Develop triangulation tracking of Type II and III radio bursts in conjunction with Wind and STEREO and investigate the relationship between long duration type III bursts and intense SEP events. (2004-2007)
- Continuing objectives from the 2001 Senior Review proposal
▪ Combine composition measurements from Ulysses with observations from ACE and SOHO to understand fractionation processes in the solar wind. (2005-2006)

the quiet, in-ecliptic slow wind reveals (Fig. 3.5) that the permanent, quiet-time proton tail spectrum above $W \approx 2.3$ at 5.26 AU is stronger and harder than at 1 AU. The most plausible mechanism for producing the tails is some statistical acceleration in the quiet solar wind. Knowing which acceleration mechanism requires additional observations. Combining Ulysses *UFC* observations between 2 and 5AU with ACE at 1 AU and Cassini data beyond 5 AU will complete the spatial and temporal characterization of the tails over a full solar cycle,.

4. *Theme 2 The Sun and Heliosphere as an Integrated System*

Research Objectives for FY2002-2004 from the Ulysses 2001 Senior Review Proposal

(1) Further investigate the influence of corotating interaction regions (CIRs) on acceleration and transport of energetic particles at high latitudes that was discovered during U-I.

(2) Provide a better test of the role of drifts in the solar modulation of solar and galactic cosmic rays in the 2nd half-Hale cycle. Investigate propagation of energetic particles throughout the inner heliosphere during a period of simplifying magnetic structure.

(3) Determine the effect of field irregularities on cosmic rays and determine their properties in the fast wind as PCHs grow.

(4) Observe inner source pickup ions in different latitudes and phases of the solar cycle from Ulysses and ACE to determine their 3D spatial distribution. Establish the connection between inner source pickup ions and their production from dust grains.

(5) Continue to collect statistics for studies of rare cosmic ray isotopes. Ulysses and ACE together will provide both the confirmation that comes from independent measurements of composition with comparable resolution, and, as a result of Ulysses' unique orbit, maximal constraint on the modulation model parameters and corrections necessary to derive interstellar abundances.

(6) Test models describing the dynamics of interstellar dust in the heliosphere.

Accomplishments in 2001-2003 and *Objectives for 2004-2005 and 2006-2007*

An example of the theme "The Sun and the Heliosphere as an Integrated System" is the study of the motion of energetic charged particles in the heliosphere, which combines data from most Ulysses instruments with global models and data from other missions. Particle motion is governed by diffusion, advection, and by gradient and curvature drifts produced by the spiral pattern of the fields. Drifts depend (Fig. 4.1) on whether the solar dipole is positive (A>0) or negative (A<0), and on particle charge, energy, and magnetic rigidity. Only measurements at widely spaced points and times permit isolating the processes leading to asymmetry in modulation. The studies reveal information about parts of the heliosphere far from Ulysses. At lower energies, particle sources are within the heliosphere (e.g., the Sun, shocks, magnetospheric boundaries). These particles provide insight into the basic physics of particle acceleration. At higher energies (>~20 MeV) sources are usually outside the inner heliosphere and particles probe the overall geometry of the heliospheric magnetic field (HMF). At the highest energies, galactic cosmic rays reflect fundamental processe of astrophysics, including nucleosynthesis, the nature of the interstellar medium, and the confinement of cosmic rays to the galaxy.

Cosmic ray modulation, CIRs, and Alfvénic fluctuations:

During U-I, Ulysses sampled the heliosphere in the first half of the Hale cycle when A>0, during declining and minimum solar activity. Cosmic ray and Alfvén wave measurements [Horbury and Balogh, 2001] confirmed that high latitude field lines are as much a barrier to inward propagating cosmic rays as the tightly wound spiral field lines at lower latitudes. During U-II, solar activity maximized and is now declining. Mixed magnetic polarities were observed at all latitudes and stream structure changed rapidly and was frequently disrupted by CMEs. With subsequent relaxation towards a solar minimum, with A<0, Ulysses will test how the latitudinal gradient of cosmic ray intensity mirrors the polarity reversal (Fig. 4.1). During the remainder of U-II (2002-2004) Ulysses will observe the effects of evolving and simplifying magnetic structure. As opposed to U-I, when Ulysses was rising in latitude as the current sheet fell in latitude, in 2003-2004 Ulysses will follow the current sheet down, most likely staying close to its maximum latitudinal reach. This will provide an opportunity to the examine latitudinal structure of modulation and particle acceleration produced by the reforming CIRs. As Ulysses approaches aphelion, it will again analyze the effects of developing PCHs and associated fast solar wind, embedded Alfvénic fluctuations, and the radial and latitudinal structure of the recovery of heavily modulated components such as the low energy anomalous component.

The full Hale cycle:

The job will not yet be complete. After 2004, as Ulysses rises through mid-southern latitudes, the heliosphere will approach solar minimum conditions with A<0. The effective source for the anomalous components should move from the poles towards the equator and drift patterns will be reversed. Of particular interest will be observations of co-rotating particle variations at high latitude. Will the reversed drift patterns magnify the high latitude effects of in-ecliptic structures? Will low energy electrons accelerated at the CIRs still be observed at high latitudes? The behavior of cosmic ray electrons has so far defied satisfactory explanation [Clem et al., 2002]. Comparing post-aphelion *UFC*-FLS data with data from the U-I fast latitude scan (FLS-I) may give quantitative and definitive answers on the role of drifts and the mechanisms of cross-field transport in propagation of energetic particles through the heliosphere (Fig. 4.1). With the launch of STEREO in 2005, a network of ecliptic, near Earth, and high latitude spacecraft will be in place to perform spatial and temporal characterization of SEPs, CIR and CME-accelerated particles, and cosmic ray modulation in the inner heliosphere.

Cross-field transport:

Studies of high latitude energetic particles and of particles accelerated and modulated by low latitude shocks and CIRs demonstrate that access to high latitudes, across the mean interplanetary magnetic field, is somehow common. These observations forced changes in existing models and a re-examination of ideas on the structure and connectivity of the HMF. Studies of cross-field transport are a central goal for *UFC*. Several specific recent results and *UFC* objectives follow.

SEPs: U-II SEP high latitude anisotropies indicate injection onto field lines inside the orbit of Ulysses [Zhang et al., 2003]. The Bastille Day event gave the first *in situ* evidence of this interplanetary cross-field diffusion in SEP events. Measurements will be extended, in *UFC*, to the declining phase of the solar cycle, supported by ecliptic measurements, to better define how the injection occurs. Onset delays for high latitude SEP events are also consistent with either latitudinal diffusion near the Sun or in interplanetary space inside the orbit of Ulysses [Dalla et al., 2003]. COSPIN measurements of protons with energies >~10 MeV in U-II showed there are often nearly equal SEP fluxes at Ulysses and Earth for extended periods in the decay phase of large SEP events. This effect implies that radial, longitudinal, and latitudinal intensity gradients in SEPs have essentially disappeared a few days after injection near the Sun [McKibben et al, 2003].

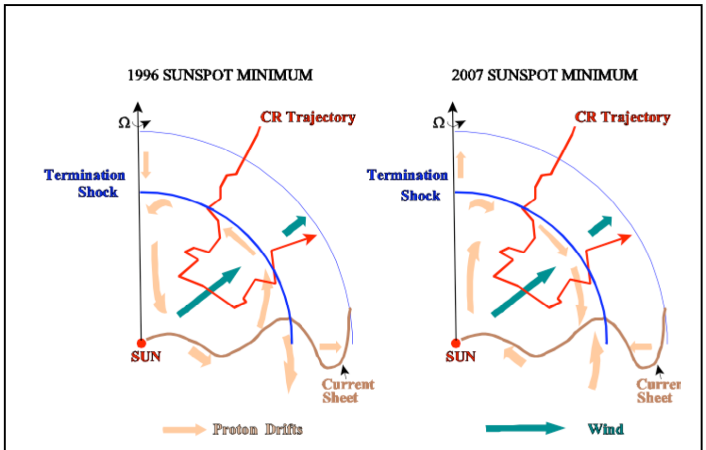

Figure 4.1. Schematic of drift patterns for energetic nucleons for positive (left panel) and negative (right panel) signs of the solar magnetic dipole field.

Jovian energetic particles: High latitude quiet-time electron increases suggest a Jovian source [Heber et al., 2002]. Their observation thus provides information about the 3D propagation of Jovian electrons and the structures (e.g, CIRs) that guide the propagation. Questions remain about what determines the episodic nature of the increases. *UFC* will extend this investigation, benefiting from the far Jupiter encounter (§7).

The anomalous cosmic ray component: ACR studies have been extended to lower energies than previously possible (~0.5 MeV/n), and the radial dependence of their disappearance in U-II, as solar maximum approached, has been characterized using measurements at 1 AU (ACE) and near 5 AU (Ulysses) [Lanzerotti & MacLennan, 2000]. Propagation inward from the heliospheric boundary should be difficult for these low energy particles, raising the possibility that they are accelerated in the solar wind, perhaps by propagating shocks associated with CMEs. Observation in the remainder of U-II and in *UFC* will help to determine this.

The studies of latitudinal transport show that understanding continues to challenge current models and ideas. The only way to disentangle the various components of the propagation process is to extend the observational basis in time and space. Comparison of observations as the magnetic structure relaxes towards solar minimum with observations made when A>0 will test the relative roles of drifts and cross-field transport. New observations should provide a diagnostic of both the effectiveness and the energy and charge dependence of the drifts and transport. Comparison of energetic nuclei and electrons will be particularly useful since electrons are much less affected by drifts.

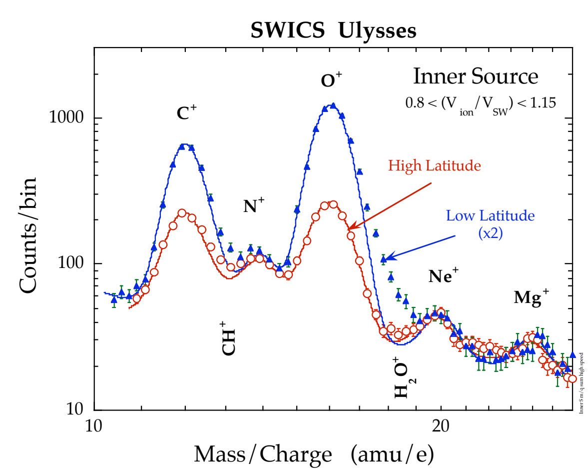

Figure 4.2. Plot of the double-coincidence counts per mass/charge (m/q) interval of ions with normalized speed W (ion speed/solar wind speed) between 0.8 and 1.15 versus the mean m/q of each interval. These measurements were made with SWICS on Ulysses at high latitudes (red open circles) and low latitudes (blue solid triangles) near solar minimum. The solid curves are fits to the data. The low-latitude inner source has 5 times more O and 3 times more C (compared to N, Ne and Mg) than the high-latitude inner source.

Beta-meteoroids:

Beta-meteoroids are sub-micron dust particles for which solar radiation pressure is comparable to, or greater than solar gravitational attraction and electromagnetic interaction with the HMF. They originate in the inner solar system and, under solar radiation pressure, move outward. Electromagnetic forces tend to carry them towards the solar poles when A>0 and confine them to low ecliptic latitudes when A<0. Spacecraft orientation prevents their detection other than at high latitudes but polar data indicate that the particles are generated within 0.5 AU of the Sun so that collisions are probably the main production mechanism [Wehry and Mann 1999]. Dust fluxes show a north-south asymmetry that cannot be explained by existing Hale cycle models. During *UFC*-FLS, beta-meteoroids will again be detectable, but at a different Hale cycle phase. This will allow a determination of the physical connection between the beta-meteoroid flux and the Hale cycle, place better constraints on beta-meteoroid production due to evaporation, and address the persistence north-south asymmetry.

Dust:

Another Hale Cycle objective in *UFC* will be to study the effect of HMF polarity reversal on the distribution of dust. Low mass interstellar dust, like beta-meteoroids, is influenced by the HMF polarity and HCS tilt. Changes in these parameters affect the dust at Ulysses after a delay of 5-6 years, the time required for the dust to be advected to a few AU. In 2005-07, Ulysses dust measurements should respond to the change from A>0 to A<0 that took place at the recent maximum. The observations will improve models and estimates of the sizes and charges of the dust.

Inner source atoms, molecules and pickup ions:

Ulysses/SWICS detected an unexpected “inner source” of C^+ in U-I and U-II [Gloeckler et al, 2000a]. The subsequent discovery of inner-source Ne^+ showed that the source material is most likely recycled solar wind. A plausible scenario [Schwadron et al., 2000] is that heliospheric grains at 10 to 30 solar radii (R_S) are saturated with solar wind material that is then released as slow-moving neutral atoms and molecules that are converted into pickup ions in the solar wind to be detected by Ulysses at distances up to 5 AU. Near solar minimum, inner-source pickup ions are observed at all latitudes. But, C/Ne and O/Ne at high latitudes are depleted compared to their abundance at low latitudes (Fig. 4.2). Inner-source pickup ions are easy to distinguish at several AU, making it possible to observe them in both low and high speed wind and to study the properties of grains at 10-30 R_S and the mechanisms that produce the neutrals. Ulysses and ACE observations will characterize the inner source, determine the 3D spatial distribution and temporal variations of the density of inner-source heliospheric grains, and improve knowledge of the composition of inner-source. Ulysses-ACE observations over a complete solar sunspot cycle (1998 to ~2008) are required.

Inner source He:

Of special interest is inner-source He. It should be present but has not yet been identified because it must be separated from interstellar He^+. There is good knowledge of the interstellar neutral He density (§5) and models for calculating the spatial distribution of interstellar He in the heliosphere have improved. There are direct measurements of the photoionization rate from SOHO/VIRGO and of the electron impact ionization rates from SWOOPS on Ulysses and ACE. With this, it is now possible to separate inner-source from interstellar He^+. Inner-source He^+ gives us a means to characterize the solar-cycle and 3D spatial distributions of heliospheric dust orbiting close to the Sun. Knowledge of dust distribution will be of importance for planning future missions, such as the Solar Probe, to the innermost (< 0.3 AU) heliosphere.

Cosmic ray abundances and galactic propagation. Rare cosmic ray isotopes:

Collection of statistics on the rarer cosmic ray isotopes will continue, and new studies will become possible with the improved statistics. Ulysses and ACE together will provide both the confirmation that comes from independent measurements of cosmic ray composition with comparable resolution. Ulysses' high latitude orbit will also provide maximal constraint on modulation models and the corrections necessary to derive interstellar abundances the evolving solar cycle.

Table 4.1: *Topical list of 2004-2007 objectives - The Sun and Heliosphere as an Integrated System*
▪ Investigate galactic and anomalous cosmic ray and SEP ion and electron gradients and drifts during and after transition to negative solar magnetic polarity to obtain a global understanding of propagation and modulation. (2004-2005)
▪ Study the 3-D structure of SEPs, CIR-accelerated particles, and cosmic rays, using the multi-point observations provided by Ulysses, STEREO, and other spacecraft. (2006-2007)
▪ Build a data base of cosmic ray, ACR, and SEP gradients and cross-field transport in an epoch when A<0 to test models and develop a better understanding of cross-field transport. (2004-2007)
▪ Apply high-latitude and Jovian flyby observations of Jovian electrons to improve understanding of interplanetary propagation of energetic electrons. (2003-2004)
▪ Measure the latitudinal extent and asymmetry of beta-meteroids to determine the significance of their evaporation close to the Sun and subsequent contribution to inner source pickup ions. (2004-2006)
▪ Determine the effect of A<0 on the distribution of dust in the heliosphere. (2005-2007)
▪ Utilize inner source pickup ion measurements, especially of He^+, by Ulysses and ACE to determine the 3-D distribution and other properties of grains at 10-30 R_S. (2006-2007)
-Continuing objectives from the 2001 Senior Review proposal
▪ Determine the properties of Alfven waves in the fast wind as PCHs grow. (2004-2006)
▪ Collect statistics for studies of rare cosmic ray isotopes. Ulysses and ACE together will provide maximal constraint on the modulation model parameters and corrections necessary to derive interstellar abundances. (2004-2007)
▪ Test models describing the dynamics of interstellar dust in the heliosphere. (2004-2007)